

# ANNALS

## OF THE SOUTH AFRICAN MUSEUM

CAPE TOWN



ANNALS OF THE SOUTH AFRICAN MUSEUM  
ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

Volume 62 Band  
August 1973 Augustus  
Part 2 Deel



CENOMANIAN AMMONITES  
FROM NOVO REDONDO, ANGOLA

By  
MICHAEL R. COOPER

Cape Town Kaapstad

The ANNALS OF THE SOUTH AFRICAN MUSEUM

are issued in parts at irregular intervals as material  
becomes available

Obtainable from the South African Museum, P.O. Box 61, Cape Town

Die ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

word uitgegee in dele op ongereelde tye na beskikbaarheid  
van stof

Verkrygbaar van die Suid-Afrikaanse Museum, Posbus 61, Kaapstad

OUT OF PRINT/UIT DRUK

1, 2(1, 3, 5, 7-8), 3(1-2, 5, t.-p.i.), 5(1-2, 5, 7-9),  
6(1, t.-p.i.), 7(1-3), 8, 9(1-2), 10(1),  
11(1-2, 5, 7, t.-p.i.), 24(2), 27, 31(1-3), 33

Price of this part/Prys van hierdie deel  
R3,60

Trustees of the South African Museum © Trustees van die Suid-Afrikaanse Museum  
1973

ISBN 0 949940 28 3

Printed in South Africa by  
The Rustica Press, Pty., Ltd.,  
Court Road, Wynberg, Cape

In Suid-Afrika gedruk deur  
Die Rustica-pers, Edms., Bpk.,  
Courtweg, Wynberg, Kaap

# CENOMANIAN AMMONITES FROM NOVO REDONDO, ANGOLA

By

MICHAEL R. COOPER

*South African Museum, Cape Town*

(With 13 figures)

[Ms. accepted 11 December 1972]

## CONTENTS

	PAGE
Introduction . . . . .	41
Geology . . . . .	42
Systematics . . . . .	43
Age of the fauna . . . . .	52
Summary . . . . .	66
Acknowledgements . . . . .	66
References . . . . .	66

## INTRODUCTION

No previous ammonite faunas have been recorded from Novo Redondo (Fig. 1), although Thiele (1933) mentioned an *Acanthoceras* sp. and the Turonian *Mammites conciliatus* (Stoliczka) from this area. The latter was probably a mis-identification of the Middle Cenomanian *Euomphaloceras cunningtoni*, the outer whorls of which take on a mammitid appearance.

Beside the well-known Upper Cenomanian locality at Salinas, few undoubted Cenomanian ammonites have been recorded from Angola. Haas (1942) described a worn *Mantelliceras*? sp., together with the new species *Sharpeiceras goliath*, from north of Cabiri. Kennedy (1971: 66) considers the latter species '... is probably not separable from *S. laticlavum*'. An unsuccessful attempt was made to locate the collecting site mentioned by Haas, but no ammonites were found. Haughton (1925: 271) referred to a *Mantelliceras* sp., SAM 6728, herein confirmed and considered to represent *M. cf. saxbii* (Sharpe), from south of Porto Amboim.

All catalogue numbers refer to the collections housed in the South African Museum. Measurement abbreviations are as follows—D, diameter; H, height, i.e. distance from umbilical seam to venter; Hi, intercostal height; Hc, costal height; Wi, intercostal width; Wc, costal width; Ui, diameter of umbilicus between umbilical seams; Uo, diameter of umbilicus between umbilical bullae; T, thickness, i.e. distance from venter of penultimate whorl to venter of final whorl. All measurements are in millimetres.

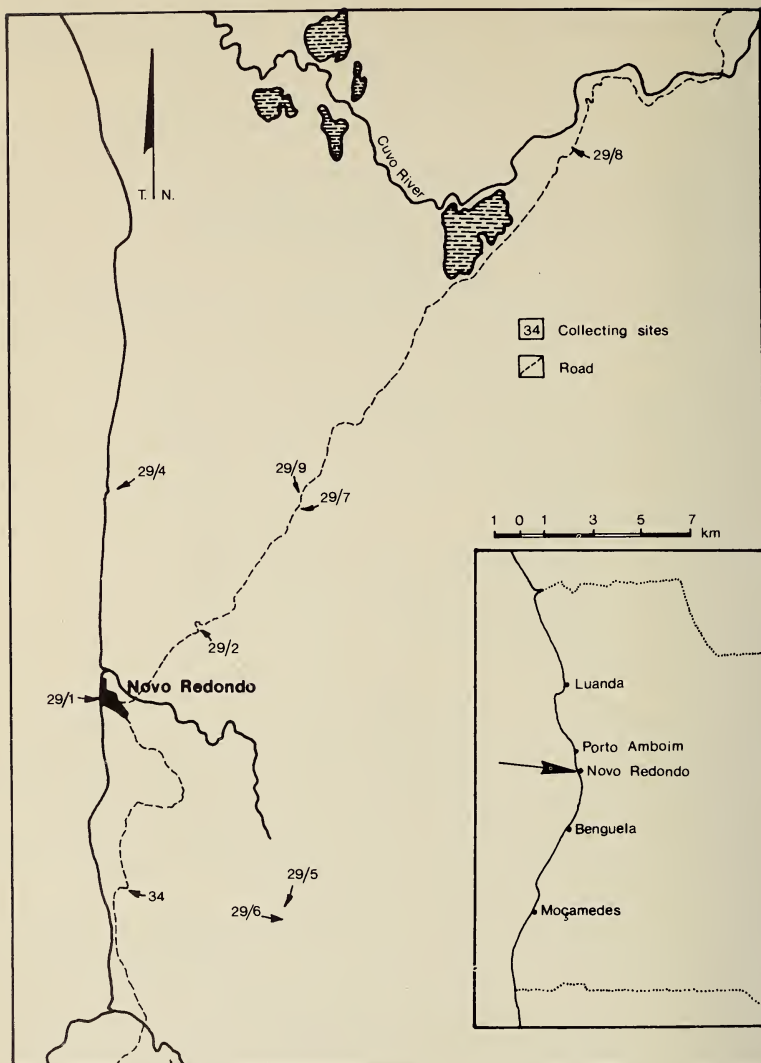


Fig. 1. Locality map.

## GEOLOGY

Post-Cretaceous folding and faulting has tended to obscure the geological relationships, but the following very broad geological sequence is apparent.

Cretaceous strata extend as far east as the Cuvo River falls, where pale, unfossiliferous silts lie directly on Basement rocks. These are followed by thin, white, extremely hard, lacustrine limestones with fresh-water molluscs (Loc. 29/8). The succeeding pale silts are overlain by gypsiferous beds. Somewhat higher up, the first marine fossils occur in sandy limestones and silts, with

the appearance of *Neithea tricostrata* (Coquand), '*Trigonia*' sp., other bivalves, gastropods, echinoids, and the ammonite *Mantelliceras*. These beds (Loc. 29/7) are of Lower Cenomanian age. Closer to Novo Redondo (Loc. 29/2) higher beds of grey, coarse-grained calcareous sandstones and grits are entirely lacking in fossils. At Novo Redondo, dark grey shales, from a trench being excavated around the perimeter of the chapel, yielded crushed specimens of *Turrilites costatus* Lamarck and *Anisoceras plicatile* (J. Sowerby), together with indeterminate acanthostrate fragments. Somewhat higher beds, exposed both to the north (Loc. 29/4) and to the south (Loc. 29/6 & 34) of the town, contain a fauna rich in echinoids and the ammonites *Turrilites acutus* Passy, *Euomphaloceras cunningtoni* (Sharpe) and *Forbesiceras obtectum* (Sharpe). Bivalves and gastropods are uncommon.

#### SYSTEMATICS

Order AMMONOIDEA Zittel, 1884

Suborder **LYTOCERATINA** Hyatt, 1889

Superfamily TURRILITACEAE Meek, 1876

Family **Hamitidae** Hyatt, 1900

Genus STOMOHAMITES Breistroffer, 1940

Type species: *Hamites virgulatus* Brongniart, 1822

*Stomohamites* aff. *simplex* (d'Orbigny)

Fig. 2E

aff. *Hamites simplex* d'Orbigny, 1842: 550, pl. 134, figs 12-14.

aff. *Stomohamites simplex* (d'Orbigny) Kennedy, 1971: 6, pl. 1, figs 1-8.

#### Description

A single, poorly-preserved hamitid, SAM K2703, appears to be related to d'Orbigny's species, mainly by virtue of their equivalent ages in the Middle Cenomanian, *S. duplicatus* (Pictet & Campiche) being a Lower Cenomanian form.

The whorl section of the Angolan specimen is unknown, but would appear to be circular. Ornament consists of radial annular ribs of which there are about seven in a distance of 5 mm, a distance approximately equal to the diameter.

#### Discussion

The unique Angolan specimen differs from *S. simplex* in its apparently finer ribbing, and is thus closer to the *Hamites simplex* figured by Collignon (1928: 55, pl. 7, figs 1-3), which Sornay (1956) and Kennedy (1971) consider to belong to another species.



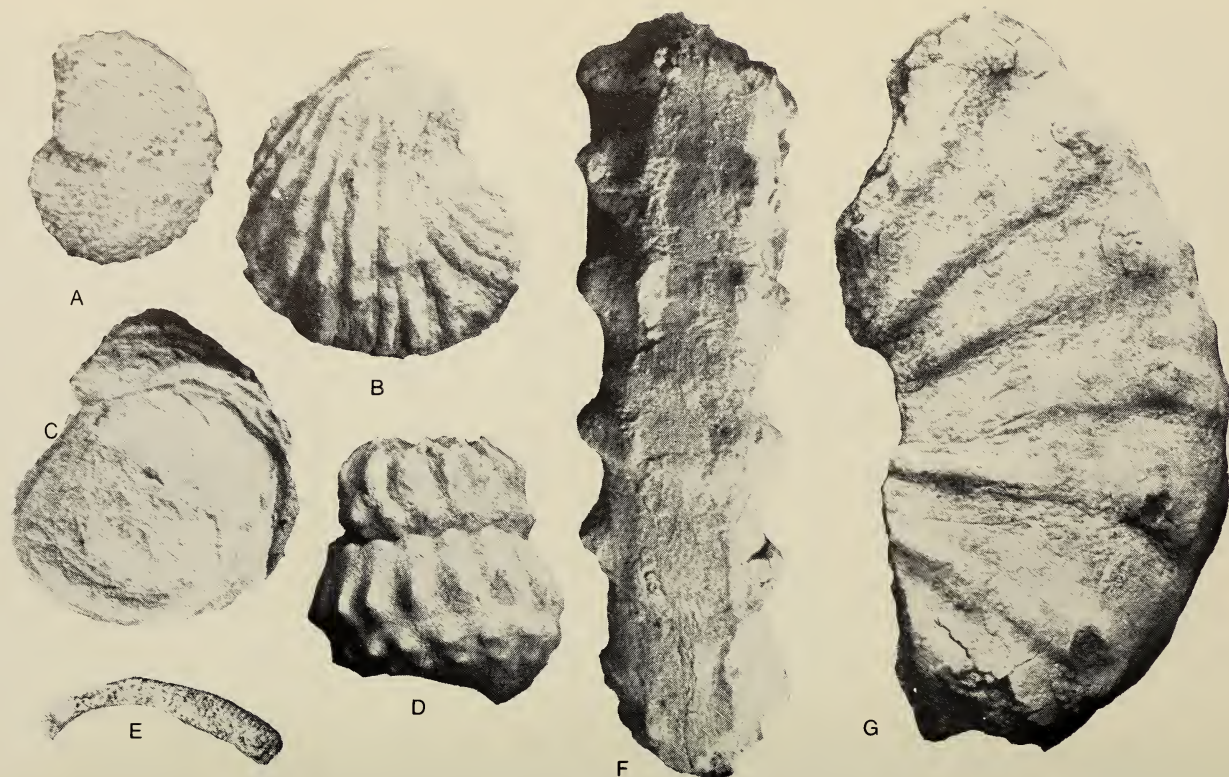


Fig. 2

A. *Forbesiceras obtectum* (Sharpe). Lateral view of poorly preserved nucleus, SAM K2700. Loc. 29/4.  $\times 2$ . B-C. *Exogyra* sp. Left and right valves of SAM K2577. Loc. 29/6.  $\times 1$ . D. *Turrilites* (*Turrilites*) *acutus* Passy. SAM K4126; lower row of tubercles concealed. Loc. 34.  $\times 1$ . E. *Stomohamites* aff. *simplex* (d'Orbigny). SAM K2703. Loc. 29/4.  $\times 1$ . F-G. *Acanthoceras* cf. *tunetana* Pervinquier. Ventral and lateral views of SAM K2928. Loc. 29/5.  $\times 2/3$ .

Family **Anisoceratidae** Hyatt, 1900Genus **ANISOCERAS** Pictet, 1854Type species: *Ammonites saussureanus* Pictet, 1847*Anisoceras plicatile* (J. Sowerby)

Fig. 3D

*Hamites plicatilis* J. Sowerby, 1819: 281, pl. 234, fig. 1.*Anisoceras plicatile* (J. Sowerby) Kennedy, 1971: 12, pl. 3, figs 12, 13; pl. 4, figs 1-3.*Description*

A single very crushed specimen, SAM K3545, is assigned to this genus by virtue of the association of two lateral ribs per ventro-lateral tubercle. It is preserved as a composite internal mould in shale.

The shell has a typical *Anisoceras* form and is loosely coiled in a single (?) plane. The whorl section is unknown. The ornament consists of rather dense, fine, flexuous, distinctly rursiradiate ribbing, narrower than the interspaces which are about 3 mm wide. There are septate spines high up on the flank, with each of which are associated two flank ribs. There are generally two ribs between each spine. The nature of the venter is unknown.

*Discussion*

The apparent lack of lateral tubercles, possibly due to crushing, makes its assignation to *Anisoceras* somewhat tentative. In all other respects, however, the ornament closely resembles *Anisoceras plicatile* which, according to Kennedy (1971: 13) '... is frequent in the lower part of the *rhodomagense* Zone'.

Family **Turrilitidae** Meek, 1876Genus **TURRILITES** Lamarck, 1801Type species: *Turrilites costatus* Lamarck, 1801*Turrilites* (*Turrilites*) *costatus* Lamarck

Fig. 3E

*Turrilites costata* Lamarck, 1801: 102.*Turrilites* (*Turrilites*) *costatus* Lamarck, Clarke, 1965: 53, figs 20a, b; pl. 20, figs 1, 2, 7, 8.

Kennedy, 1971: 30, pl. 6, fig. 3, pl. 8, figs 12-14.

*Description*

A number of crushed specimens, preserved as internal moulds, undoubtedly belong to this species, showing the characteristic development of ribs on the adapical portion of the outer whorl surface, which join the upper row of tubercles, the latter being bullate.



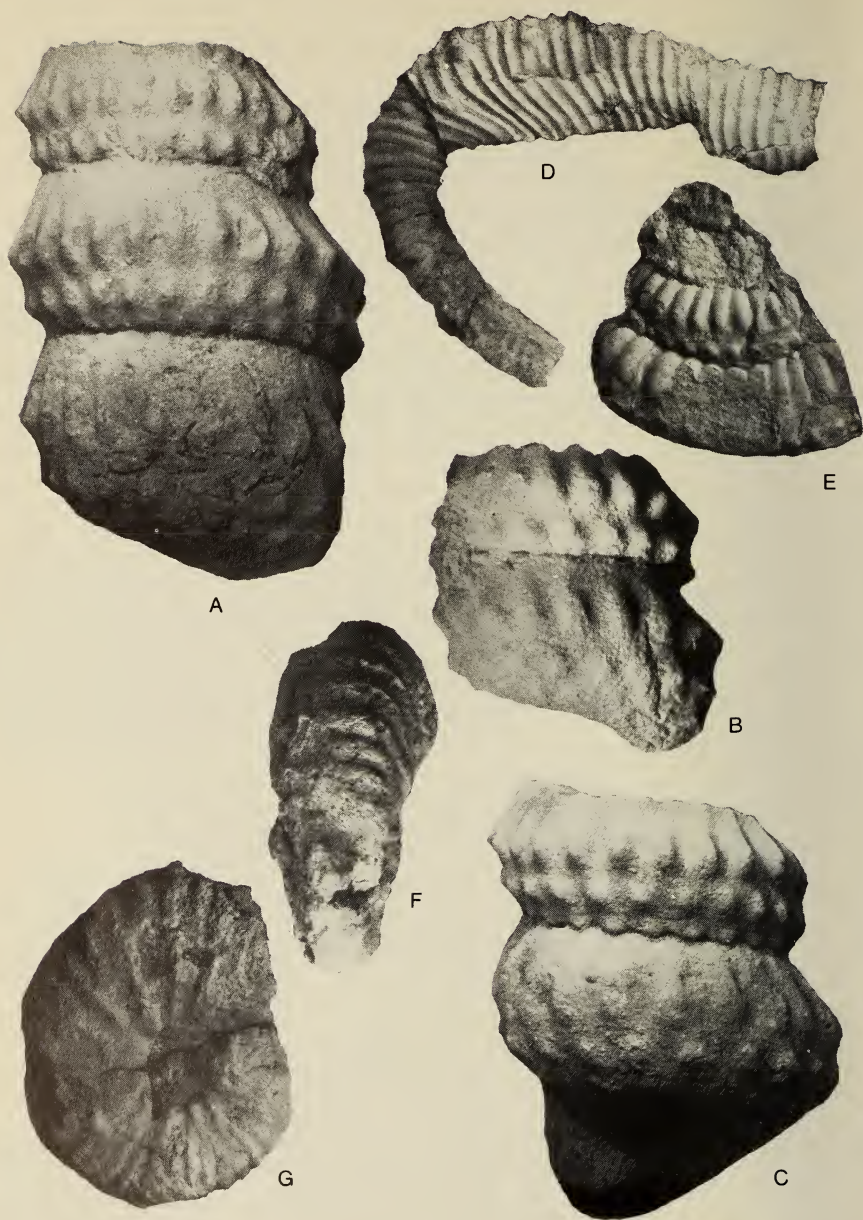


Fig. 3

A-C. *Turrilites* (*Turrilites*) *acutus* Passy. A. SAM K4101.  $\times 2/3$ . B. SAM K4103; lower row of tubercles concealed.  $\times 1$ . C. SAM K4100; lower row of tubercles exposed.  $\times 2/3$ . All from Loc. 29/6. D. *Anisoceras plicatile* (J. Sowerby). SAM K3545. Loc. 29/1  $\times 1$ . E. *Turrilites* (*Turrilites*) *costatus* Lamarck. SAM K3540. Loc. 29/1.  $\times 1$ . F-G. *Mantelliceras* cf. *saxbii* (Sharpe). Ventral and lateral views of SAM 6728.  $\times 1$ .

### Discussion

This species ranges from the top of the *Mantelliceras mantelli* zone, throughout the *rhodomagense* zone, attaining its greatest abundance at the base of the latter zone, where Kennedy (1971) has recognized a *Turrilites costatus* faunal assemblage.

### *Turrilites (Turrilites) acutus* Passy

Figs 2D, 3A-C, 8D, 13B

*Turrilites acutus* Passy, 1832: 334; Diener, 1925: 79. Collignon, 1964: 53, fig. 1489. Clarke, 1965: 54, pl. 19, fig. 7. Kennedy, 1971: 30, pl. 7, figs 7, 8.

*Turrilites dearingi* Stephenson, 1952: 30, pl. 44, figs 6-8. Clarke, 1965: 55, pl. 20, fig. 4. Kennedy, 1971: 31.

### Description

This well-known species is represented by numerous large examples from Novo Redondo, both with the lower row of tubercles exposed, as in *T. dearingi*, or concealed, as in *T. acutus*, indicating the two 'species' to represent nothing more than intra-specific variation.

The shell is spirally coiled, sinistral, with a very acute spiral angle. The whorls are in contact, with the outer face gently convex intercostally, but angular, polygonal in costal section.

The outer face is ornamented with three spiral rows of prominent tubercles, arranged on weak, oblique ribs, of which there are 19-20 per whorl. The upper tubercles are the most prominent and are somewhat bullate, lying slightly above mid-flank. The lower pair of tubercles are more conical, and not as prominently developed. The distance between the middle and upper row of tubercles is greater than that between the middle and lower row. The lowest row may be exposed (Fig. 3C), or concealed (Fig. 3B) by the succeeding whorl. The upper line of contact of each whorl is crenulated. The lower surface is gently convex and lacking in ornament. The upper whorl surface is strongly concave, with an acute shoulder. The suture-line is well preserved in some of the specimens (Fig. 4).

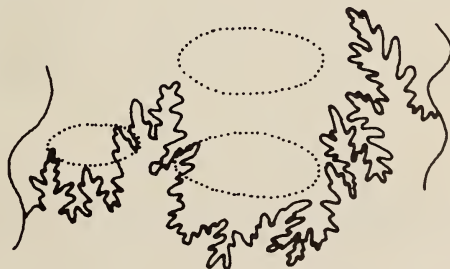


Fig. 4

Suture-line of *Turrilites acutus* Passy.  $\times 2\frac{1}{2}$ .

A single, aberrant specimen (Fig. 13B) develops a shallow spiral groove between the middle and upper row of tubercles, slightly above mid-flank, on the final two whorls, and is associated with the disappearance of the upper row of tubercles and a marked weakening of the lower two rows. Other specimens at similar, and larger, growth stages show no sign of this phenomenon.

#### Discussion

Kennedy (1971: 31) pointed out that the only difference between *T. acutus* and *T. dearingi* was that the lower row of tubercles was exposed on the outer flanks of the whorls of the latter species, and concluded that this species '... may merely be an aberrant *T. acutus*'. Whilst the Angolan material shows *T. (Turrilites) dearingi* not to be aberrant, it must be considered to fall within the intra-specific limits of *T. acutus*. From the Angolan material it appears that the lower row of tubercles is covered during the early ontogenetic stages, becoming exposed with age.

Superfamily DESMOCERATACEAE Zittel, 1895

Family **Desmoceratidae** Zittel, 1895

Subfamily **Puzosiinae** Spath, 1922

Genus PUZOSIA Bayle, 1878

Type species: *Ammonites subplanulatus* Schlüter, 1871

?*Puzosia* sp. indet.

#### Description

A puzosiid fragment is referable to either this genus or *Austiniceras*. The specimen is moderately large, with an evenly-arched venter and slightly convex flanks, which converge towards the venter. The venter is ornamented with distinct, narrow, prorsiradiate ribs which form a chevron across the venter. There are six ribs within a 15 mm distance along the venter.

Superfamily ACANTHOCERATACEAE Hyatt, 1900

Family **Lyelliceratidae** Spath, 1921

Subfamily **Forbesiceratinae** Wright, 1952

Genus FORBESICERAS Kossmat, 1897

Type species: *Ammonites largilliertianus* d'Orbigny, 1841

*Forbesiceras obtectum* (Sharpe)

Figs 5, 6A-B

*Ammonites obtectus* Sharpe, 1853: 20, pl. 7, figs 4a-c.

*Forbesiceras obtectum* (Sharpe) Kennedy, 1971: 47, pl. 16, fig. 3; pl. 9, figs 3a, b; pl. 46, fig. 3

#### Description

This species, together with *Turrilites acutus* Passy, forms the most abundant component of the Novo Redondo fauna and is represented by gigantic oxycones,



nearly all of which are, unfortunately, weathered composite internal moulds. Consequently, the ornament is known only from a single, small, specimen, SAM K2684. It is extremely involute and compressed, discoidal, with broad, slightly convex flanks. The very narrow venter is slightly convex, with a faint median keel. The ribbing is extremely faint, but is visible as strongly prorsiradiate striae on the inner half of the flanks. The outer half of the flanks shows rursiradiate ribbing projecting strongly backwards. The suture-line is well preserved in a number of specimens (Fig. 5).



Fig. 5

Suture-line showing first lateral saddle of *Forbesiceras obtectum* (Sharpe), SAM K2541.  $\times 1$ .

#### Measurements

No.		D.	H.	W.	T.
SAM K2684	..	118	79	28	?
SAM K2688	..	?	140	49	100
SAM K2691	..	305	?	$\pm 60$	?
SAM K2692	..	295	?	$\pm 50$	?
SAM K2687	..	195	$\pm 120$	42	$\pm 90$

#### Discussion

According to Kennedy (1971: 46) *Forbesiceras* is a medium-sized, rare ammonite genus. Neither of these statements is applicable to the Novo Redondo forms which are both extremely abundant and extremely large. Small nuclei of this genus (Fig. 2A), and presumably this species, occur at Locality 29/4 and show distinct ventro-lateral tubercles, with slightly prorsiradiate ribbing on the outer parts of the flank.

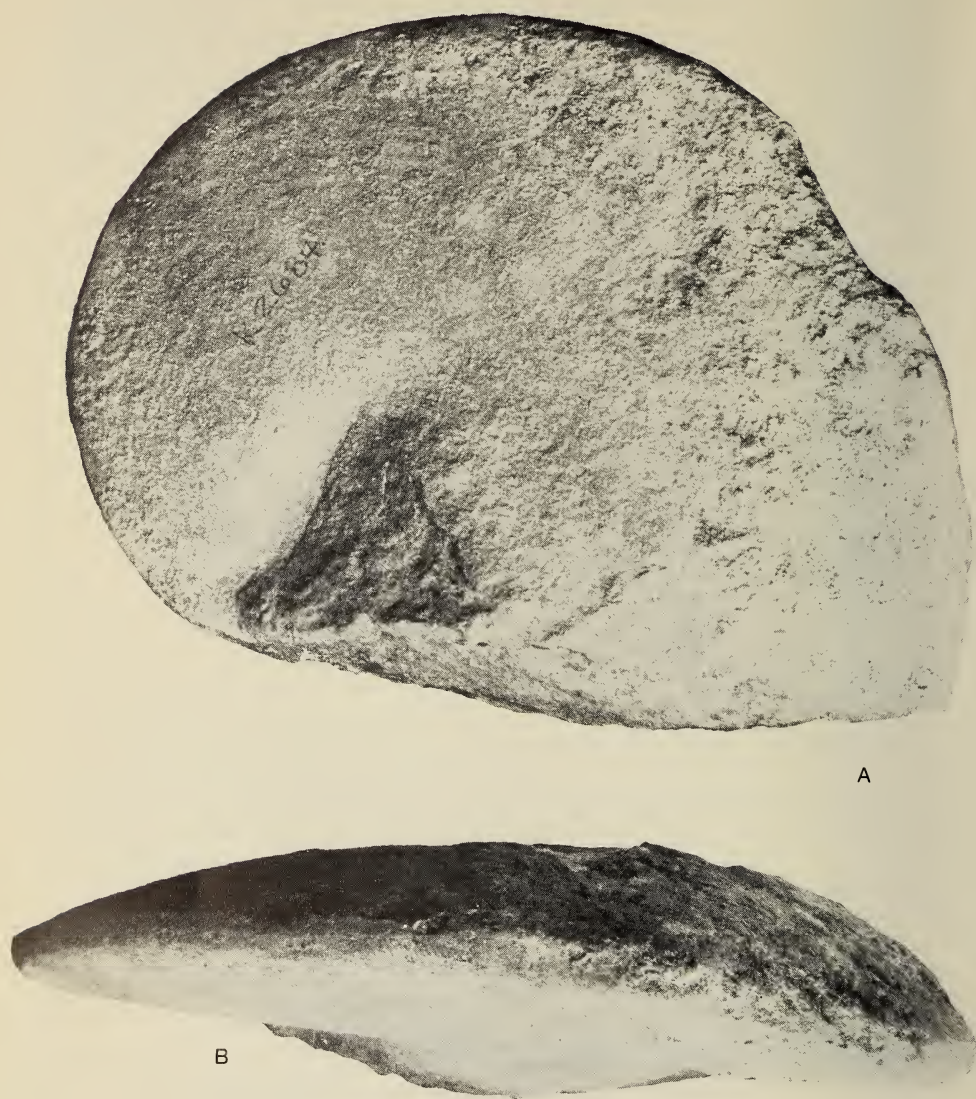


Fig. 6

A-B. *Forbesiceras obtectum* (Sharpe). Lateral and ventral views of SAM K2684. Loc. 29/6.  $\times 1$ .



Family **Acanthoceratidae** Hyatt, 1900Subfamily **Mantelliceratinae** Hyatt, 1900Genus **MANTELLICERAS** Hyatt, 1900Type species: *Ammonites mantelli* J. Sowerby, 1814*Mantelliceras* cf. *saxbii* (Sharpe)

Figs 3F-G; 7C-D

cf. *Ammonites saxbii* Sharpe, 1857: 45, pl. 20, figs 3a, b.cf. *Ammonites mantelli* Sharpe, 1857: 40, pl. 18, figs 4a, b only (*non* Sowerby).cf. *Ammonites feraudianus* Sharpe, 1857: 51, pl. 23, figs 6a-c (*non* d'Orbigny).cf. *Mantelliceras hyatti* Spath, 1925: 197.cf. *Mantelliceras ventnorense* Diener, 1925: 170. Kennedy, 1971: 62, pl. 26, figs 2a-c.*Description*

A single somewhat worn specimen, SAM K2506, was collected from the lowest fossiliferous marine horizon studied (Loc. 29/7). It is matched by an almost identical specimen, SAM 6728, from the 'sea-cliffs south of Benguela Velha (Porto Amboim)', discussed by Haughton (1925: 271) and now figured (Figs 3F-G).

The Novo Redondo specimen, SAM K2506, is preserved as a composite internal mould. The shell is compressed, with a whorl height: whorl width ratio of 1.25, and rather involute. The umbilicus is deep and fairly narrow, with a steep umbilical wall and a subrounded shoulder. The broad flat flanks converge slightly to the narrow, evenly-rounded venter. The ornament comprises alternating long and short prorsiradiate ribs, the former arising from small but distinct umbilical bullae. All ribs are ornamented with both upper and lower ventro-lateral tubercles. There are 15 ribs per half whorl, of which 7 are long ribs. The umbilical bullae extend on to the umbilical walls as radial primary ribs. The ribs pass straight up the flank to lower ventro-lateral tubercles, from which they bend sharply forwards to the upper ventro-lateral tubercles before joining across the venter. The latter is flat between the upper ventro-lateral tubercles.

*Measurements*

No.		D.	H.	Wi.	Wc.	Ui.	Uo.	T.
SAM K2506	..	40	20	16	?	9	15	?
SAM 6728	..	41	20	18	?	10	16	?

*Discussion*

*Mantelliceras mantelli* (J. Sowerby) differs from this species in being more inflated, with an octagonal whorl section, and in possessing mid-lateral tubercles. *Mantelliceras lymense* (Spath) is more finely ribbed than the Angolan example, with 25 ribs per half whorl, of which 7 are long ribs arising from



Fig. 7

A-B. *Calyoceras coleroonense percostata* Collignon. Lateral and ventral views of SAM K2571. Loc. 29/6.  $\times 1$ . C-D. *Mantelliceras* cf. *saxbii* (Sharpe). Lateral and ventral views of SAM K2506. Loc. 29/7.  $\times 1$ .

umbilical bullae, whereas there are only 15 per half whorl in the Novo Redondo specimen. Kennedy & Hancock (1971) considered *M. ventnorense* Diener closely related to *M. saxbii*, and of doubtful specific status. This species has about 34 alternating long and short flexuous ribs per whorl, and is thus very close to the Angolan specimen. The ribbing in the latter is straight, however, and not flexuous.

The Angolan specimen bears a close resemblance to the holotype of *M. hyatti* Spath, considered a synonym of *M. saxbii* by Kennedy & Hancock (1971), but is more coarsely ribbed. The Isle of Wight specimen has 19 ribs per half whorl at a slightly larger diameter, of which 9 are long ribs. However, Houghton's example from Porto Amboim has a similar number of ribs, but appears to increase rather rapidly in inflation on the anterior portion of the outer whorl.

#### Genus CALYCOCERAS Hyatt, 1900

Type species: *Ammonites navicularis* Mantell, 1822

*Calycoceras coleroonense percostata* Collignon

Figs 7A–B

*Calycoceras coleroonense* Stoliczka var. *percostata* Collignon, 1964: 118, pl. 361, fig. 1584.

? *Calycoceras newboldi* var. *ankomakaensis* Collignon, 1937: 16, pl. 3, figs 7, 7a; pl. 8, fig. 6.

Collignon, 1964: 120, pl. 362, fig. 1588.

#### Description

Two slightly crushed specimens appear to belong to this subspecies. Both are preserved as composite internal moulds.

In SAM K2571, which has suffered slight lateral compression, the shell is compressed and evolute, with a wide, shallow umbilicus and a rounded umbilical shoulder. The flanks are almost flat and converge slightly to the evenly rounded venter. The outer whorl increases very slowly in height.

The ornament comprises rather dense, rounded, slightly flexuous ribs, generally alternating long and short, although occasionally there may be two short ribs intercalated between adjacent long ribs. The long ribs are ornamented with small but distinct umbilical bullae, while all ribs show the faintest hint of lower ventro-lateral swellings, and small, but distinct, upper ventro-lateral clavi. On the posterior portion of the outer whorl siphonal tubercles are very weakly developed. There are about 22 ribs per half whorl, 11 of which are long ribs. The greatest width is at the umbilical shoulder.

For comparative purposes measurements of other species are included below, with percentages in brackets.



*Measurements*

	No.		D.	H.	Wi.	Wc.	Ui.	Uo.	T.
SAM	K2571	..	94	35(37)	34(36)	35	?	52	?
	1	..	71	(41)	(42)	—	(35)	—	—
	2	..	61	(48)	(48)	—	(26)	—	—
	3	..	114	(39)	(43)	—	(32)	—	—
	4	..	105	(40)	(43)	—	(32)	—	—

The other species are as follows: 1 the type species of *C. newboldi ankoma-kaensis*; 2 the specimen figured by Collignon (1964); 3 the type species of *C. coleroonense percostata*; 4 the type species of *C. sinuosum*.

*Discussion*

*Calycceras coleroonense* (Stoliczka) has flat flanks, with 25–35 ribs per whorl, and a sulcate venter in mature forms, although Stoliczka (1861: 71) considered the ‘. . . chief distinctive character of this species lies in the very gradual increase of the whorls in height and in the septa’. The Angolan form does not have a concave venter, while the ribbing is denser.

*Calycceras coleroonense percostata* Collignon was erected for a more densely ribbed variety with 45 ribs per whorl, in which the venter was only very slightly concave, a feature not apparent in the figure. There appears no difference whereby the Angolan form can be separated from this subspecies.

*Calycceras sinuosum* Collignon has the same general form as *C. coleroonense percostata*, indeed the measurements are virtually identical, with about 42 ribs per whorl, but apparently has finer, more flexuous ribbing. The differences are slight.

*Calycceras newboldi newboldi* (Kossmat) is more inflated, with a narrower umbilicus, fewer, stronger ribs, and more prominent tuberculation. *Calycceras newboldi ankomaensis* Collignon differs from the type in having flatter flanks, more evolute coiling, more ribs (42), higher whorls, and weaker tuberculation. It thus closely approaches *C. coleroonense percostata*. A comparison of the dimensions of these two forms shows that the type of *C. newboldi ankomaensis* is transitional between the smaller example figured by Collignon (1964: 120, pl. 362, fig. 1588) and the larger holotype of *C. coleroonense percostata*. It seems possible that the differences in the Madagascan species are due to comparison of different ontogenetic stages.

*Calycceras annulatum* Collignon

Figs 8A–C

*Calycceras annulatum* Collignon, 1964: 127, pl. 366, figs 1597, 1598.

*Description*

Two fragments of the outer whorls of rather large forms are assigned to this species, both preserved as composite internal moulds.

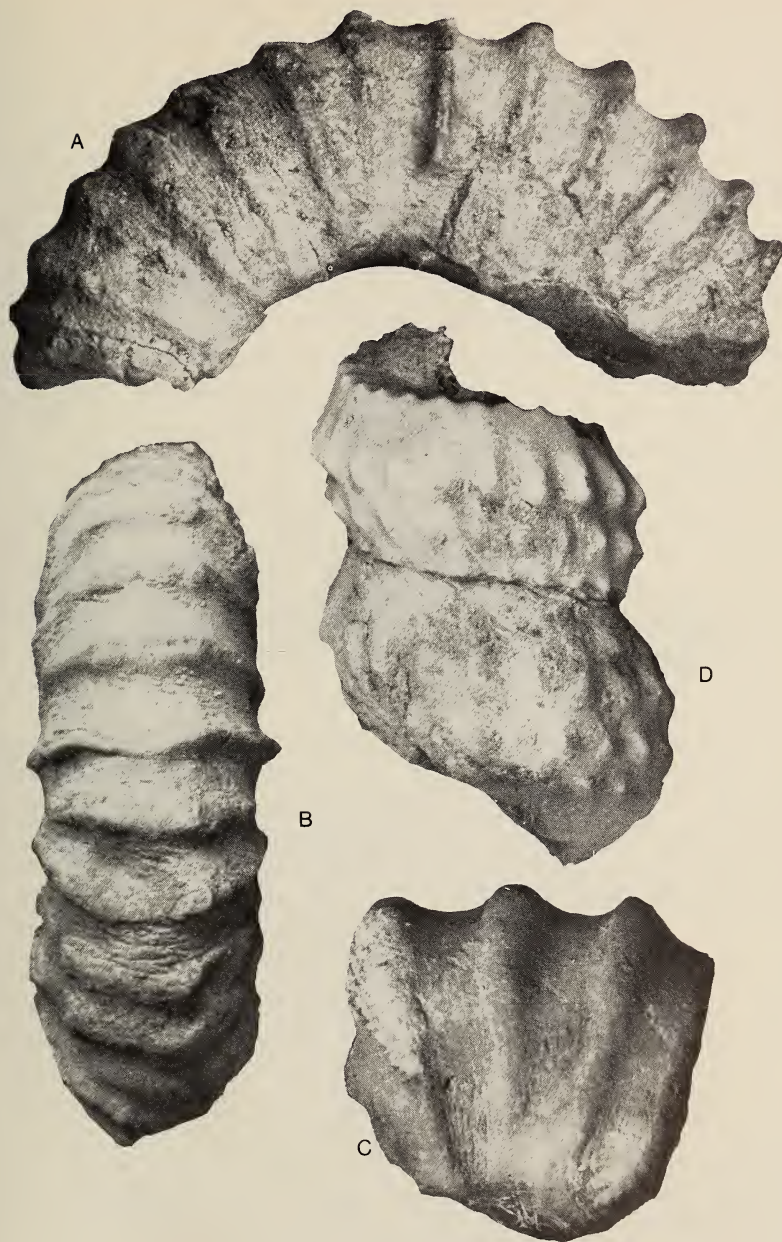


Fig. 8

A-C. *Calycoceras annulatum* Collignon. A-B. lateral and ventral views of SAM K2559.  $\times 2/3$ . C. lateral view of SAM K2580.  $\times 2/3$ . Both from Loc. 29/6.  
D. *Turrilites (Turrilites) acutus* Passy. SAM K2568. Loc. 29/6.  $\times 2/3$ .



In SAM K2559 the whorl section is slightly compressed, oval intercostally and with an angular, polygonal costal section. The umbilicus was wide and probably rather shallow, with sloping umbilical walls and an evenly-rounded umbilical shoulder. The flanks are convex and converge towards the rounded venter. Ornament comprises long and short ribs, which do not alternate. Thus, while 7 ribs arise at the umbilical shoulder only 10 cross the venter. The long ribs are ornamented with weak, strongly bullate umbilical tubercles, while all ribs have rather weak lower ventro-lateral tubercles and more prominent upper ventro-lateral tubercles. The ventro-lateral tubercles are also bullate due to the peculiar nature of the ribbing. The ribs are radial and very strongly flared, especially across the venter where the interspaces are strongly concave. Across the venter the costal section is slightly concave between the upper ventro-lateral tubercles. There is no sign of siphonal tubercles.

SAM K2580, which represents a much larger, still septate, growth stage and presumably belongs to this species, has fewer flared ribs, whilst also showing the faintest sign of siphonal clavi.

#### Measurements

No.	D.	Hi.	Hc.	Wi.	Wc.	Ui.	Uo.	T.
SAM K2559	$\pm 140$	42	45	39	42	$\pm 53$	?	?
SAM K2580	?	48	52	43	$\pm 48$	?	?	?

#### Discussion

The distant, prominently flared, ribbing of this species, recorded from the 'Lower Cenomanian' Zone à *Mantelliceras mantelli* et *Calycoceras newboldi* of Madagascar, is distinctive. The relation between this large species and the small *Calycoceras paucinodatum* (Crick), also associated with *Turrilites acutus*, requires looking into, especially in view of '... the considerable range of variation admitted in this species (*C. paucinodatum*)' by Kennedy (1971: 77).

#### Genus EUCALYCOCERAS Spath, 1923

Type species: *Ammonites pentagonus* Jukes-Browne, 1896

*Eucalycoceras* sp.

Figs 9C-D; 10C-D

#### Description

Two very worn fragments belong to this genus. Both are preserved as composite internal moulds.

The first example, SAM K2593, is a distinctly compressed form, with convex sides, converging slightly to the flattish venter. The maximum width is at the umbilical shoulder. Sinuous, slightly prorsiradiate long ribs arise either singly or in pairs from weak umbilical bullae. There is invariably one, occasionally two, shorter intercalated ribs between adjacent long ribs. There

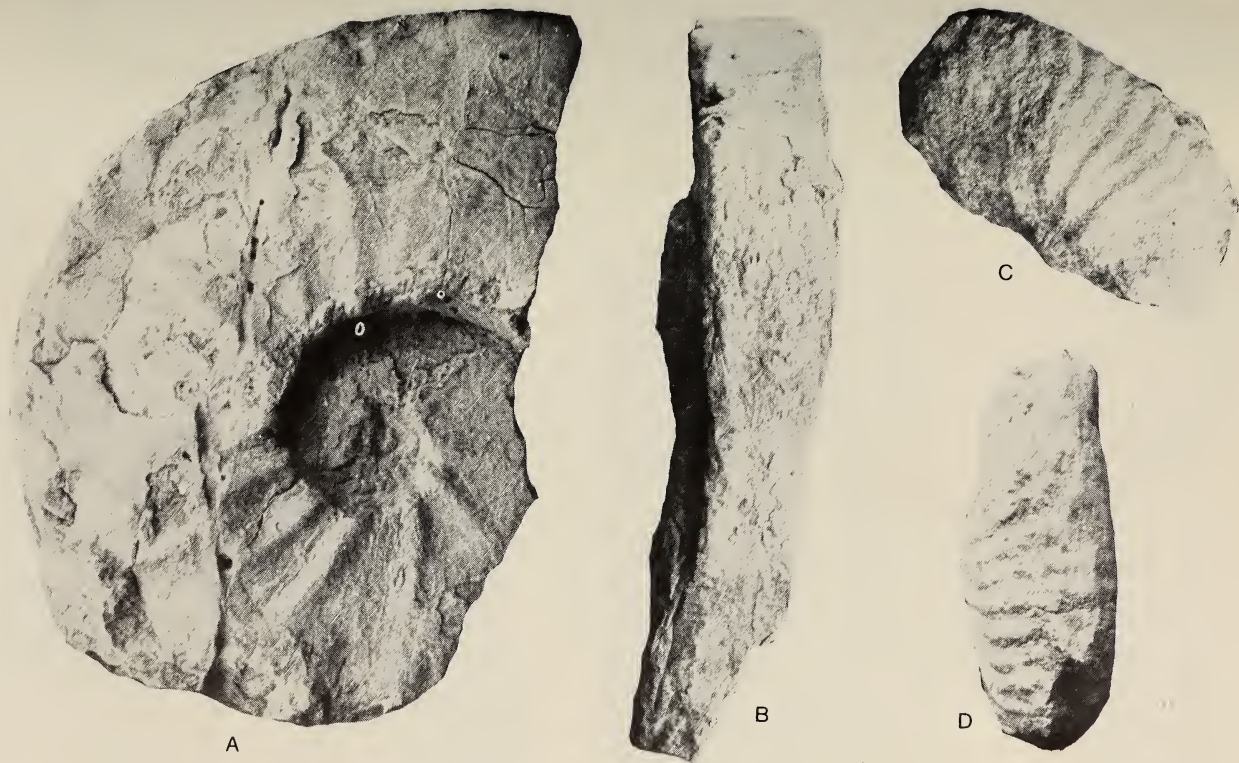


Fig. 9

A-B. ?*Acanthoceras* sp. aff. *tunetana* Pervinquière. Lateral and ventral views of SAM K2558, showing complete absence of ventral tuberculation, tabulate venter, and strongly compressed form. Loc. 34.  $\times 2/3$ . C-D. *Eucalycoceras* sp. Lateral and ventral views of SAM K2593. Loc. 29/6.  $\times 1$ .



Fig. 10

A-B. *Euomphaloceras cunningtoni meridionale* (Pervinquière). Lateral and ventral views of SAM K2554. Loc. 29/6.  $\times 1$ .  
C-D. *Eucalycoceras* sp. Ventral and lateral views of SAM K2595. Loc. 29/6.  $\times 1$ .



are very weak lower ventro-lateral tubercles and upper ventro-lateral clavi. The venter is not preserved.

The second example, SAM K2595, would appear to have similar flank ornament to the above specimen, whilst also showing the nature of the venter. The latter is flattish with distinct upper ventro-lateral clavi joined across the venter by ribs which show faint siphonal swellings.

#### Measurements

No.			D.	H.	W.	Uo.	Ui.	T.
SAM K2593	..	..	?	22	19	?	?	?
SAM K2595	..	..	?	23	20	?	?	21

#### Discussion

The undoubtedly evolute, high-whorled form and flat flanks suggest that the above specimens belong to *Eucalycoceras* rather than *Calycoceras*. The appearance of this genus in the *Turrilites acutus* assemblage is at an earlier stage than any British occurrence. According to Kennedy (1971: 81) '... the earliest English *Eucalycoceras* appear at the top of the *rhotomagense* Zone'. *E. gothicum* (Kossmat) has umbilical tubercles projecting into the umbilicus; *E. pentagonum* (Jukes-Browne) has less flexuous, denser ribbing which is effaced at mid-flank at about the growth stage of the Angolan specimens. It also has more prominent siphonal tuberculation, as well as being an Upper Cenomanian form. *Eucalycoceras rowei* Spath is also an Upper Cenomanian form, closely resembling the above specimens, but also with denser, less flexuous ribbing.

#### Subfamily *Acanthoceratinae* Hyatt, 1900

##### Genus ACANTHOCERAS Neumayr, 1875

Type species: *Ammonites rhotomagensis* Brongniart, 1822

*Acanthoceras* cf. *tunetana* Pervinqui re

Figs 2F-G

cf. *Acanthoceras confusum* (Gu ranger) var. *tunetana* Pervinqui re, 1907: 268, pl. 13, figs 4a, b.  
cf. *Acanthoceras tunetana* Pervinqui re, Kennedy, 1971: 90, pl. 40, fig. 5.

#### Description

Numerous crushed fragments preserved in green shales would appear closest to this species. However, the state of preservation of the Angolan material leaves much to be desired and comparison is difficult.

The largest and best-preserved specimen, SAM K2928, was almost certainly very compressed and evolute. The umbilical wall is steep, with a subrounded umbilical shoulder. The flanks are broad and flat, with a narrow, tabulate venter. Ornament comprises sharp, well-rounded ribs which begin

close to the umbilical seam, and pass backwards (rursiradiate) to the umbilical shoulder where they swell slightly to form distinct umbilical bullae. There are occasional intercalated ribs. From the bullae slightly prorsiradiate, convex forwards, ribs pass up the flanks to prominent, swollen lower ventro-lateral tubercles. Faint ribbing joins the lower ventro-lateral tubercles across the narrow, almost flat venter, and is ornamented with weak upper ventro-lateral clavi. There is no sign of siphonal tuberculation.

Abundant smaller examples, presumably assignable to this species, all very fragmentary and crushed, differ only in having closer, more prominent ribbing and much weaker tuberculation.

A complete, but somewhat crushed example, SAM K2558 (Figs 9A–B) shows similarities to the other Angolan forms and is thus doubtfully included within this genus. This specimen is strongly compressed and very evolute. The umbilicus is rather wide and shallow with a rather broad, vertical umbilical wall and an angular umbilical shoulder. The broad flanks are flat and parallel. The ventro-lateral shoulders are acute, with a narrow, tabulate venter. Ornament on this specimen comprises fairly prominent umbilical bullae which give rise to distinctly prorsiradiate ribs that fade away before mid-flank. There is no other sign of ornament. This specimen differs from the above described material largely in the absence of tuberculation. The acute nature of the ventro-lateral shoulder furthermore seems to suggest that the lack of tuberculation is not due to erosion. Consequently, even the generic assignation of this specimen becomes difficult.

#### Measurements

No.		D.	H.	W.	Ui.	T.
SAM K2558	..	132	55	±28	35	?

#### Discussion

The distant ribbing, compressed form and prominent lower ventro-lateral tubercles of this form are characteristic. *Euomphaloceras alvaradoense* (Moreman) (Stephenson 1955: 63, pl. 7, figs 1–9) from the uppermost Cenomanian basal Eagle Ford of Texas bears a superficial resemblance, presumably due to convergence.

Kennedy (1971) assigned a specimen from the *Turrilites acutus* faunal assemblage of southern England to *Acanthoceras tunetana*, but it differs from the type, and the Angolan material, in having swollen, rounded umbilical tubercles and not bullae.

The Angolan example figured differs from the type in having slightly closer ribbing, being more compressed and having prorsiradiate, not rursiradiate, ribbing.



## Genus EUOMPHALOCERAS Spath, 1923

Type species: *Ammonites euomphalus* Sharpe, 1855*Euomphaloceras cunningtoni meridionale* (Stoliczka)

Figs 10A-B; 11; 12A-B; 13A

*Ammonites meridionalis* Stoliczka, 1864: 76, pl. 41, figs 1a-c.*Acanthoceras meridionale* (Stoliczka) Pervinquière, 1907: 278, pl. 15, figs 2-6.*Euomphaloceras meridionale* (Stoliczka) Matsumoto *et al.*, 1969: 272, pl. 33, figs 1, 2; pl. 34, fig. 1; text-fig. 6.*Euomphaloceras cunningtoni meridionale* (Stoliczka) Kennedy, 1971: 93.*Description*

This species is the most abundant of the well-preserved acanthocerates from these beds. The shell is very evolute and strongly depressed, with a sub-rectangular intercostal section. The costal section is angular, polygonal. The umbilicus is wide and deep, with a steep umbilical wall and rounded umbilical shoulder. The flanks are flat and parallel, and rather narrow. The venter is broad and slightly convex.

All the specimens are preserved as composite internal moulds. External ornament comprises distinct umbilical bullae, which extend very faintly on to the umbilical wall. On the earlier growth stages these bullae are weakly connected to prominent lower ventro-lateral spines on the ventral shoulder, by single, radial ribs. From the lower ventro-lateral spines, ribs arise in looped pairs, occasionally with an intercalated rib between spines. Each rib is ornamented with upper ventro-lateral and siphonal tubercles. Thus, at about 80 mm diameter, in SAM K2554, there are 19 upper ventro-lateral and siphonal tubercles associated with only 9 lower ventro-lateral spines. At this stage the latter point diagonally outwards.

With age the siphonal tubercles disappear and the ventro-lateral tubercles amalgamate to form prominent horns. At this stage the flank ribs become much more prominent and robust. The suture-line is preserved in SAM K2552 and is reproduced in Figure 11.

*Measurements*

No.	D.	Hc.	Hi.	Wi.	Wc.	Ui.	Uo.	T.
SAM K2552 ..	±120	54	45	60	71	±60	?	?
SAM K2554 ..	81	33	29	44	48	31	45	?
SAM K2554 ..	±50	20	20	33	38	15	26	?
SAM K2557 ..	?	64	57	67	79	?	?	54

*Discussion*

*Euomphaloceras cunningtoni meridionale* (Stoliczka) differs from *E. cunningtoni cunningtoni* (Sharpe) in that the latter has more siphonal than upper ventro-

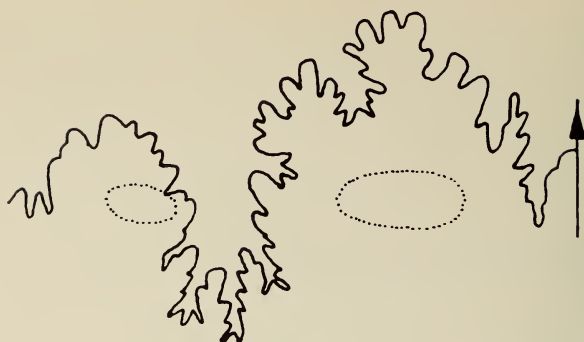


Fig. 11

Suture-line, slightly eroded, of *Euomphaloceras cunningtoni meridionale* (Pervinquière), SAM K2552.  $\times 1$ .

lateral tubercles. Both these varieties are well treated by Kennedy (1971). The holotype is from the top of the *Turrilites costatus* faunal assemblage of Wiltshire.

#### *Aptychus* sp.

##### *Description*

A single small *Aptychus* was collected at Novo Redondo in association with indeterminate acanthocerate fragments, *Turrilites costatus* and *Anisoceras plicatile*, and is consequently of low Middle Cenomanian age.

The specimen is preserved as an internal mould, and has a strongly trigonal shape. The inner margin was broken during extraction, but it formed almost a right angle with the harmonic margin. The surface of the mould, i.e. the inner surface of the *Aptychus*, is ornamented with very fine, concentric striae which fade away on the adharmonic ridge.

##### *Discussion*

The specimen seems closest to *Spinaptychus* Trauth, but the latter is known only from Senonian beds, commonly in association with *Texanites* (Klinger 1971). Consequently its generic assignation is uncertain.

#### AGE OF THE FAUNA

The most detailed biostratigraphic subdivision of the Cenomanian is that of Kennedy (1971) for southern England. This author has recognized 5 biostratigraphic zones:

##### Upper Cenomanian:

*Metoicoceras gourdoni* Zone

*Metoicoceras gestlinianum* Zone

*Calycoceras naviculare* Zone



Fig. 12

A-B. *Euomphaloceras cunningtoni meridionale* (Pervinquière). Lateral and ventral views of fragment of outer whorl of mature individual, SAM K2557, showing coalescence of ventro-lateral tubercles to form horns, and disappearance of siphonal tubercles. Loc. 29/6.  $\times 2/3$ .



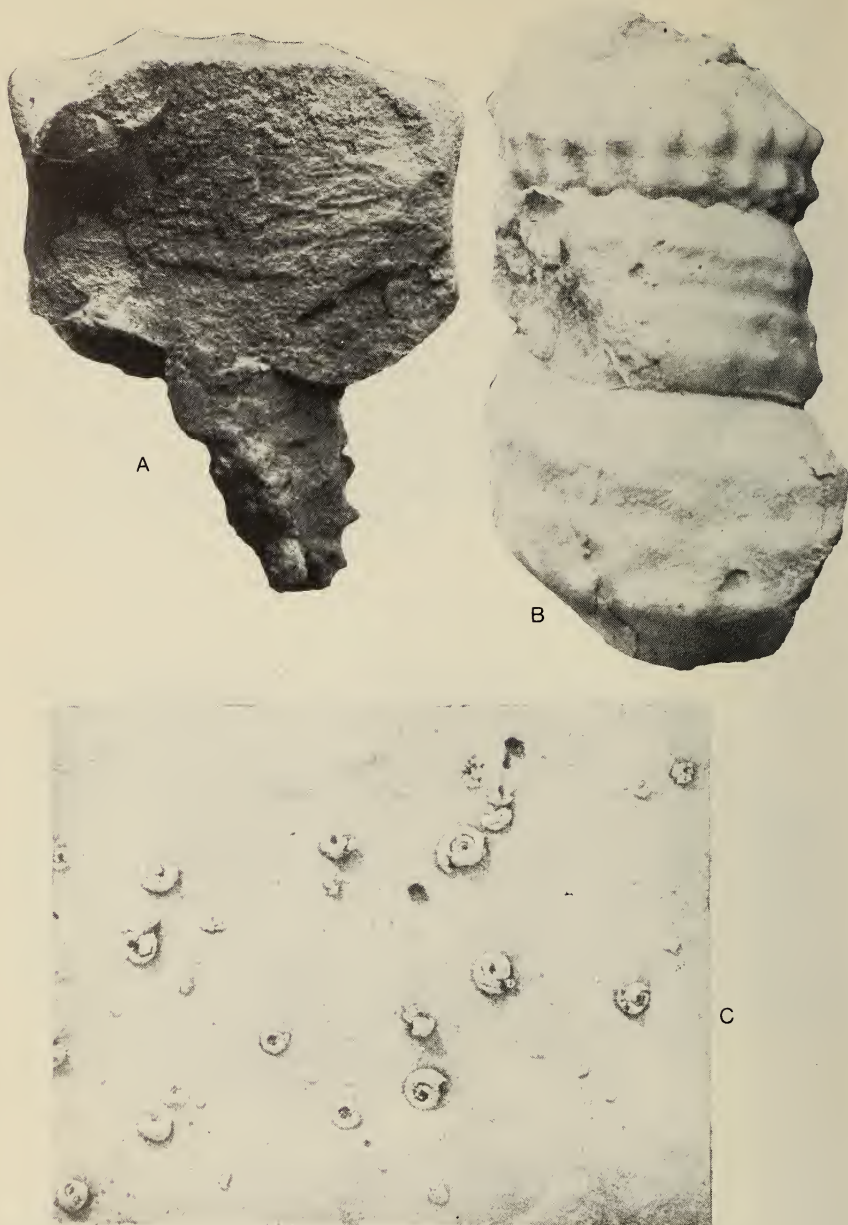


Fig. 13

A. *Euomphaloceras cunningtoni meridionale* (Pervinquière). Front view showing whorl section of SAM K4106. Loc. 29/6.  $\times 1$ . B. *Turrilites* (*Turrilites*) *acutus* Passy. ?Aberrant specimen SAM K2543 showing shallow spiral groove at about mid-whorl on body chamber. Loc. 29/6.  $\times 1$ . C. Tiny ammonite nuclei, probably acanthoerate, crowded on bedding plane. SAM K2695. Loc. 29/4.  $\times 2$ .

## Middle Cenomanian:

*Acanthoceras rhotomagense* Zone

## Lower Cenomanian:

*Mantelliceras mantelli* Zone

Confined to the Lower Cenomanian are the genera *Mantelliceras*, *Sharpeiceras* and *Hyphoplites*, while the heteromorph *Hypoturritites* is particularly abundant in this stage. The strata near Novo Redondo yielding *Mantelliceras* cf. *saxbii* may therefore be assigned to this stage.

The Middle Cenomanian is marked by the appearance of the genera *Acanthoceras* and *Calycoceras*. Kennedy (1971: 102) recognized three stratigraphically separate faunal assemblages within this zone, some of the more important faunal constituents of which are listed below:

*Acanthoceras jukesbrownei* faunal assemblage:

*Acanthoceras jukesbrownei* (Spath) and related forms dominate this assemblage, together with *Scaphites equalis* J. Sowerby and *Calycoceras* spp. *Turritites costatus*, *T. acutus* and *T. scheuchzerianus* Bosc are all rare.

*Turritites acutus* faunal assemblage:

*Acanthoceras rhotomagense* (Brongniart) and related forms are common in this assemblage which is characterized by the abundance of *T. acutus*. Also common are *Calycoceras paucinodatum* (Crick), *C. newboldi* (Kossmat) and related forms, *Austiniceras austini* (Sharpe), etc., while *Euomphaloceras cunningtoni*, *Forbesiceras oblectum*, *Turritites costatus* and *Acanthoceras tunetana* have been recorded.

There is little doubt that the faunas at Novo Redondo, characterized by the abundance of *Turritites acutus* and *Forbesiceras oblectum*, correspond to this faunal assemblage.

*Turritites costatus* faunal assemblage:

Especially common in this assemblage are *Turritites costatus*, *Sciponoceras baculoide* (Mantell), *Anisoceras plicatile*, and *Acanthoceras* of the *rhotomagense* group. It seems likely that the crushed fauna occurring in green shales around the chapel at Novo Redondo may be assigned to this faunal assemblage.

Thus, not only are the faunal associations at Novo Redondo virtually identical with those recorded by Kennedy (1971) from southern England, but the same ammonite succession may also be recognized, thereby providing ample evidence for the validity of this biostratigraphic zonation.

The well-documented Cenomanian ammonite faunas of Madagascar (Collignon 1964) are at present of little biostratigraphic value, since the zonal scheme recognized by Collignon (1964) undoubtedly represents collecting from different palaeontological horizons. Most of the Angolan species are, however, known from this island.

From Zululand Crick (1907) has recorded a rich *Turritites acutus* faunal assemblage, dominated by *Calycoceras* spp., *T. acutus*, *Acanthoceras* of the *rhotomagense* group, together with *T. costatus*, *T. scheuchzerianus*, *Forbesiceras largillierianum* (d'Orbigny), etc.



## SUMMARY

A typical Cenomanian fauna characterizes Novo Redondo and environs. The lowest beds, although poorly fossiliferous, have yielded examples of the Lower Cenomanian *Mantelliceras* cf. *saxbii* (Sharpe). A higher horizon at Novo Redondo itself contains *Turrilites costatus* Lamarck and *Anisoceras plicatile* (J. Sowerby), and is correlated with the *Turrilites costatus* faunal assemblage of low Middle Cenomanian age. To the north and south of the town alternating limestones and shales are rich in *Turrilites acutus* Passy, *Euomphaloceras cunningtoni* (Sharpe), *Forbesiceras obiectum* (Sharpe), *Calycoceras annulatum* Collignon, *Acanthoceras* cf. *tunetana* Pervinqui re, and *C. coleroonense percostata* Collignon. No higher beds were recorded from this area. The ammonite succession and faunal associations are virtually identical with those recorded from southern England by Kennedy (1971).

## ACKNOWLEDGEMENTS

I should like to thank Dr W. J. Kennedy of Oxford for his constructive criticism of the manuscript. The assistance given to me in Angola by the Instituto de Investiga  o Cient fica de Angola is gratefully acknowledged.

## REFERENCES

- CLARKE, D. L. 1965. Heteromorph ammonoids from the Albian and Cenomanian of Texas and adjacent areas. *Mem. geol. Soc. Am.* **95**: 1-99.
- COLLIGNON, M. 1928. Pal ontologie de Madagascar. xv. Les c phalopodes du C nomanien pyr teux de Diego-Suarez. *Annls Pal ont.* **17**: 139-160.
- COLLIGNON, M. 1929. Pal ontologie de Madagascar. xv. Les c phalopodes du C nomanien pyr teux de Diego-Suarez. *Annls Pal ont.* **18**: 1-56.
- COLLIGNON, M. 1933. Fossiles c nomaniens d'Antsatramahavelona. *Annls g ol. Serv. Mines Madagascar* **3**: 50-80.
- COLLIGNON, M. 1937. Ammonites c nomaniennes du sud-ouest de Madagascar. *Annls g ol. Serv. Mines Madagascar* **8**: 28-72.
- COLLIGNON, M. 1939. Fossiles c nomaniens et turoniens du Menabe. *Annls g ol. Serv. Mines Madagascar* **10**: 61-126.
- COLLIGNON, M. 1964. *Atlas des fossiles caract ristiques de Madagascar (Ammonites)*. **XI**, C nomanien. Tananarive: Service g ologique.
- COLLIGNON, M. 1966. Les c phalopodes cr t ces du bassin c tier de Tarfaya. *Notes M m. Serv. Mines Carte g ol. Maroc* **175**: 1-148.
- CRICK, G. C. 1907. Cretaceous fossils of Natal. Part III. *Rep. geol. Surv. Natal Zululand* **3**: 161-250.
- HAAS, O. 1942. Some Upper Cretaceous ammonites from Angola. *Am. Mus. Novit.* **1182**: 1-24.
- HAUGHTON, S. H. 1925. Notes on some Cretaceous fossils from Angola (Cephalopoda and Echinoidea). *Ann. S. Afr. Mus.* **22**: 263-288.
- KENNEDY, W. J. & HANCOCK, J. M. 1971. *Mantelliceras saxbii* (Sharpe) and the horizon of the Martimpreyi Zone in the Cenomanian of England. *Palaeontology* **14**: 437-454.
- KENNEDY, W. J. 1971. Cenomanian ammonites from southern England. *Spec. Pap. Palaeont.* **8**: 1-133.
- KLINGER, H. 1971. The possible association of *Spinptychus* with the genus *Texanites*. *Ann. geol. Surv. S. Afr.* **7**: 105-109.
- MOREMAN, W. L. 1942. Palaeontology of the Eagle Ford Group of north and central Texas. *J. Paleont.* **16**: 192-220.

- PERVINQUIÈRE, L. 1907. *Études de paléontologie tunisienne*. I. Céphalopodes des terrains secondaires. (Régence de Tunis . . . Carte géologique de la Tunisie.) Paris: De Rudeval.
- SORNAY, J. 1956. [*Hamites simplex* d'Orbigny 1840.] *Palaeont. univers.* (n.s.) **18**: [1-2].
- STEPHENSON, L. W. 1952. Larger invertebrate fossils of the Woodbine Formation (Cenomanian) of Texas. *Prof. Pap. U.S. geol. Surv.* **242**: 1-226.
- STEPHENSON, L. W. 1955. Basal Eagle Ford fauna (Cenomanian) in Johnson and Tarrant Counties Texas. *Prof. Pap. U.S. geol. Surv.* **274-C**: 53-65.
- STOLICZKA, F. 1863-1866. The fossil Cephalopoda of the Cretaceous rocks of southern India. *Mem. geol. Surv. India Palaeont. indica* (3) **1-13**: 41-216.
- THIELE, S. 1933. Neue Fossilfunde aus der Kreide von Angola mit einem Beitrag zur Stammesgeschichte der Gattung *Pervinqueria* Böhm. *Zentbl. Miner. Geol. Paläont.* (B) **1933**: 110-123